1-1-1995

Biotechnology: exposing the myths & realities

Sue Sutherland
Alan Lymbery

Follow this and additional works at: http://researchlibrary.agric.wa.gov.au/journal_agriculture4

Part of the Animal Sciences Commons, Biotechnology Commons, Molecular Genetics Commons, and the Plant Breeding and Genetics Commons

Recommended Citation
Available at: http://researchlibrary.agric.wa.gov.au/journal_agriculture4/vol36/iss2/3

This article is brought to you for free and open access by Research Library. It has been accepted for inclusion in Journal of the Department of Agriculture, Western Australia, Series 4 by an authorized administrator of Research Library. For more information, please contact jennifer.heathcote@agric.wa.gov.au, sandra.papenfus@agric.wa.gov.au.
IMPORTANT DISCLAIMER

This document has been obtained from DAFWA's research library website (researchlibrary.agric.wa.gov.au) which hosts DAFWA's archival research publications. Although reasonable care was taken to make the information in the document accurate at the time it was first published, DAFWA does not make any representations or warranties about its accuracy, reliability, currency, completeness or suitability for any particular purpose. It may be out of date, inaccurate or misleading or conflict with current laws, polices or practices. DAFWA has not reviewed or revised the information before making the document available from its research library website. Before using the information, you should carefully evaluate its accuracy, currency, completeness and relevance for your purposes. We recommend you also search for more recent information on DAFWA's research library website, DAFWA's main website (https://www.agric.wa.gov.au) and other appropriate websites and sources.

Information in, or referred to in, documents on DAFWA's research library website is not tailored to the circumstances of individual farms, people or businesses, and does not constitute legal, business, scientific, agricultural or farm management advice. We recommend before making any significant decisions, you obtain advice from appropriate professionals who have taken into account your individual circumstances and objectives.

The Chief Executive Officer of the Department of Agriculture and Food and the State of Western Australia and their employees and agents (collectively and individually referred to below as DAFWA) accept no liability whatsoever, by reason of negligence or otherwise, arising from any use or release of information in, or referred to in, this document, or any error, inaccuracy or omission in the information.
Biotechnology has become one of the buzz words of the 1990s. Sounds impressive but what's it really all about? Sue Sutherland and Alan Lymbery unravel some of the jargon and explore its potential for Western Australian agriculture.

Biotechnology involves harnessing the natural biological processes of microbes and plant and animal cells for the benefit of mankind. But already, the products of biotechnology are all around us and have been for many years. Yoghurt, beer, wine and cheese are all examples of biotechnology. Even a compost bin is a biotechnology factory as it harnesses the natural chemical processes of living organisms.

The techniques of modern biotechnology and molecular biology, in particular genetic engineering, have opened up exciting new possibilities in the agricultural industries and offer hope of meeting the challenges of the future.

Biotechnology is helping produce healthier, more productive farm animals and new food plants at lower cost and with more efficient use of resources. Biotechnology has also led to a new generation of rapid diagnostic kits that can be mass produced and require little or no training to use. These tests are highly specific for their target substance, and can be applied in the field, on the farm or in industry.

Genetic engineering
The primary aim of modern biotechnology is to make a living cell perform a specific useful task in a predictable and controllable way. The task could be to make lupins resistant to cucumber mosaic virus (CMV) or to transfer disease or parasite-resistant genes from one breed of sheep or cattle to another.

Whether a living cell can perform these tasks is determined by its genetic make-up, that is by the instructions contained in a collection of chemical messages called genes. These genes are passed from one generation to the next, so that offspring inherit a range of individual traits from their parents.

The chemical coding system underlying these genes is based on a substance called deoxyribonucleic acid (DNA). A gene is a segment of DNA which has a message encoded in its chemical structure.

Biotechnology provides tools for isolating genetic material (DNA).

Modern genetic engineering is the science of manipulating and transferring chemical instructions from one cell to another. Such changes can be achieved within a single generation, without the slow and unpredictable processes of breeding. They can also incorporate desirable genes from totally unrelated species.

The primary aim of modern biotechnology is to make a living cell perform a specific task

Black tulips, blue roses – all possible with biotechnology.
Transgenic plants and animals

Organisms whose genetic make-up has been altered using these techniques are called transgenic or genetically modified organisms.

Transgenic plants and animals result from genetic engineering experiments in which genetic material is moved from one organism to another, so that the latter will exhibit a desired characteristic. Scientists, farmers and business corporations hope that transgenic techniques will allow more precise and cost-effective plant and animal breeding programs.

Improved quality, productivity, breeding and marketability for crop plants

Benefits to growers come from increases in yield, quality and market value of cereal grains and grain legumes. One project at the Department of Agriculture, aims to identify markers in plant material for its starch component. The starch component is recognised as critical in determining suitability of wheat for production of white Japanese noodles – udon – an important end-use of our wheat.

Productivity and efficiency could be increased for all crops by the provision of insect and disease-resistant plants or by developing sensitive diagnostic procedures for diseases of plants.

The Department of Agriculture provides a seed testing service for lupin growers to help them decide whether they can sow their own seed without undue risk from CMV infection. One genetic test can detect the presence of the genetic code of CMV in a ground sample of dry lupin seed. This service tests over a thousand samples a year.

Studies of plant physiology, genetics, and molecular biology have led to many novel breeding techniques in recent years. These complement conventional breeding programs, extending the range of genetic material available and shortening the time required to create a commercial product.

For example, breeding for improved quality and specific traits in crops is being undertaken at the Centre for Legumes in Mediterranean Agriculture (CLIMA) based at the University of Western Australia. A new lupin strain has been bred, by genetic engineering, to have resistance to the herbicide Basta®. Use of the herbicide-resistant variety should provide additional weed control options to lupin growers.

New flower varieties

An Australian company is conducting glasshouse trials of roses with genetically modified flower colour. In one proposal, roses contain an extra copy of a gene (one that is already present in the rose) that codes for an enzyme involved in production of flower pigments. The extra copy of the gene inhibits enzyme production, leading to pink flower petals instead of red.

In another proposal, the gene inserted into the rose was the blue gene from petunia. The gene codes for an enzyme required for synthesis of pigments responsible for blue flowers.

Better pastures

The Department of Agriculture has undertaken to develop a DNA test to enable fast, accurate definition of races of a fungus that cause severe damage on subterranean clover. About 4 million hectares in Australia are sown with clover and the potential loss from the fungus is enormous.

Rapid identification of any new races of the fungus would allow future outbreaks to be contained, while continuing to use resistant clovers. Such a test would also benefit clover breeding by defining the fungi that cause the most damage to pasture.

Cartoon reproduced from SEARCH: Science and Technology in Australia and New Zealand with permission of Control Publications.
CSIRO’s Division of Plant Industries in Canberra is looking at improving productivity of subterranean clover through genetic engineering of virus resistance and leaf protein quality. Researchers are proposing a field trial of subterranean clover into which a gene for sunflower seed albumin has been inserted. The albumin is rich in sulphur-containing amino acids which resist breakdown in the sheep rumen. The modified clover has the potential to provide improved nutrition, particularly for wool growth. The Department of Agriculture is associated with this project by providing the base genetic material and subsequently field testing selected transgenic lines.

**Improving pasture use**

Biotechnology can be used both to produce better quality feed plants and also to genetically engineer rumen bacteria for better digestive efficiency. The Meat Research Corporation has financed a research program, based mainly in the tropical grassland areas of Australia, to study the feasibility of inserting genes into rumen bacteria to improve their digestion of plant fibre. These engineered bacteria can then be used to colonise the rumen of sheep and cattle to enable the animals to better use feed plants, especially low-quality tropical grasses.

**Tools for better disease control**

Effective treatment and control of infectious diseases requires rapid, specific and highly sensitive diagnostic tests. Biotechnological approaches are based on the premise that disease organisms carry unique sequences of DNA that, if isolated, can be used to construct a test with which to search the tissues of sick animals. If the test finds the DNA sequence, then that particular virus, bacteria or parasite is present.

DNA detection tests are not only sensitive, but very rapid. Our Animal Health Laboratories have developed a DNA test which can identify *Mycobacterium bovis* (the bacterium which causes tuberculosis in cattle), in one to two days compared with six to twelve weeks for traditional methods.

The Department is also at the forefront of the search for a DNA test to identify virulent strains of the bacterium which causes footrot in sheep. Determining the potential for footrot to develop on a property is complicated by the occurrence of different strains of bacteria which differ in their ability to cause disease. A test to distinguish virulent from benign strains would provide more flexibility in control measures.

Rapid treatment of sick animals is an important part of maintaining the health of a herd or flock. Another approach to disease control is prevention. The natural resistance of animals to disease varies between individuals, and is to a large extent genetically controlled.

The Department’s Katanning office has been running a selection project since 1989 to enhance resistance to gastro-intestinal parasites in sheep (see story on page 56). They have improved resistance to parasite infection in the selected sheep, as measured against controls. The project has now moved to using genetic engineering to breed more resistant sheep by searching for DNA markers of resistance.

**New approaches to breeding**

Marker-assisted selection is a direct approach to finding genetically superior animals. It involves developing a test to identify a gene (or marker) which either determines a particular trait, or is located on the same chromosome as other genes which determine the trait.

The advantages of marker-assisted selection are that selection is more accurate, because genes are identified directly, and that selection can occur earlier in life, at birth or even in embryos.

The list of traits for which marker genes have been found is growing. Identifications have been made for genes which determine several metabolic disorders, horn development and milk production in cattle, fertility in sheep, and meat quality in pigs.

Tests for some of these genes are being developed commercially. The most pressing requirement is for research on the best ways to incorporate marker-assisted selection into existing genetic improvement schemes.

**Determining pedigrees**

DNA fingerprinting is the biotechnological equivalent of using the patterns of whorls on fingerprints for uniquely identifying individuals. It uses the fact that some regions of DNA are
extremely variable and can differ between almost all individuals in a species. Unlike the fingerprints on your hand, DNA fingerprints are precisely inherited from generation to generation. They can therefore positively identify an animal’s parents.

DNA fingerprinting of livestock in Australia was pioneered by the Department of Agriculture, in collaboration with Curtin University. The technique is now widely used to provide checks on herd book registrations and to resolve disputed pedigrees. In the future, it could have much broader applications.

In many beef cattle and sheep breeding enterprises, especially those in pastoral areas, dams have the opportunity to mate with several sires that range freely with them. The prospects for genetic improvement through performance-based selection schemes are very limited, because paternity of calves is uncertain. Routine application of DNA fingerprinting would allow paternity to be determined without having to adopt single-sire mating.

Transgenic animals: something for the future?

Cattle, sheep and pigs with foreign genes have been produced in the laboratory. The long-term aim of this technology is to insert genes which boost production.

Commercial application, however, is severely limited because it is difficult to identify the right genes to insert, and it is difficult to control their expression so as to obtain the desired effect, while at the same time avoiding disruption of other biological functions.

Of more immediate, though somewhat more limited promise, is the technique of ‘gene pharming’. This is the use of animals to produce pharmaceuticals and other substances that are hard to synthesise artificially, by inserting into them foreign genes which will produce the desired product. This technology will very soon be a commercial reality in Europe and the USA. It has not yet been tried in Australia.

Social implications

The application of genetic engineering, especially transgenic technology, to agriculture has often been accompanied by feelings of unease and sometimes by outright criticism. The objections can be grouped into concern about the safety of engineered food; adverse environmental effects, for example from the dispersal of genetically engineered crop plants; compromised welfare of transgenic or otherwise modified animals; inequitable application of the technology, for example to the advantage of large businesses in developed countries; and the morality of manipulating and patenting life forms.

These concerns are important and should not be dismissed. But, it is important to understand that genetic engineering provides no more than a set of tools for manipulating the DNA of organisms. These tools have enormous application across all areas of biology, but it is their application, not the tools themselves, that determines the ethical value of biotechnology.

The future for all our agricultural commodities lies in developing export markets. But in these markets we face rising consumer awareness of food quality and increasing concerns over health and safety. We also face competition from increasingly efficient primary producers overseas. At home we must deal with the problems of environmental degradation and our responsibility to implement sustainable farming practices.

These problems existed before the biotechnological revolution and biotechnology need not contribute to them. Instead it can help us to solve them.

It can provide us with the ability to increase our primary production enormously without increasing our area of farmland; to precisely alter the characteristics of a product to meet market specifications or to conform to health guidelines; to virtually eliminate application of herbicides, insecticides and anthelminthics by making our crops and livestock resistant to pests; to ensure the health and safety of farmed animals without the scourge of inherited diseases and management practices which may compromise welfare; to produce scarce pharmaceutical products in a quantity and at a price available to everyone; and to export not only our primary produce but also our technology to those areas of the world which are unable to feed themselves.

Biotechnology gives us the tools to develop a competitive, sustainable, export-oriented agricultural industry. All we need to do is to ensure that these tools are developed properly and used appropriately.

Sue Sutherland is Biotechnology Coordinator for the Department of Agriculture and can be contacted on (09) 368 3343.

Alan Lymberry is a geneticist based at Bunbury and can be contacted on (097) 255 255.